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GB 1319282
"Welding Process Technology" P.T. Huuldcroft (Camb Univ Press)
P.86 Fig. 50
P.104 Fig. 61
P.117-121
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(54) **Use of liquefied gas in hot dip metal coating**

(57) When hot dip coating a substrate with metal a blanket of non-reactive vaporised liquefied gas is created over the surface of molten metal in which the substrate is dipped so as to prevent or reduce oxidation of the molten metal. Liquid nitrogen is sprayed from nozzles 14 of a spray header 12 along or at the surface of the molten metal 6. The liquid nitrogen vaporises, and the so-formed vapour is drawn across the surface of the molten metal, providing an 'inert' blanket of gas thereacross, by means of a fan 22. The vapour is collected in a hood 16 on the side of the tank 2 opposite the nozzles 14.

Steel may be hot dip coated with Zn, Al or Sn.

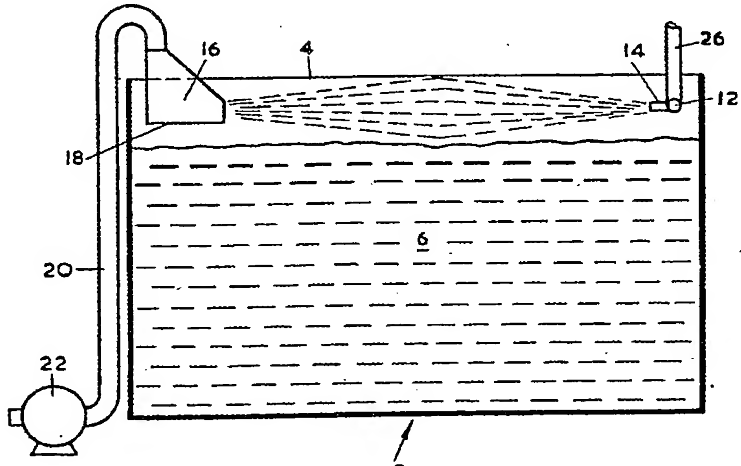

FIG.I

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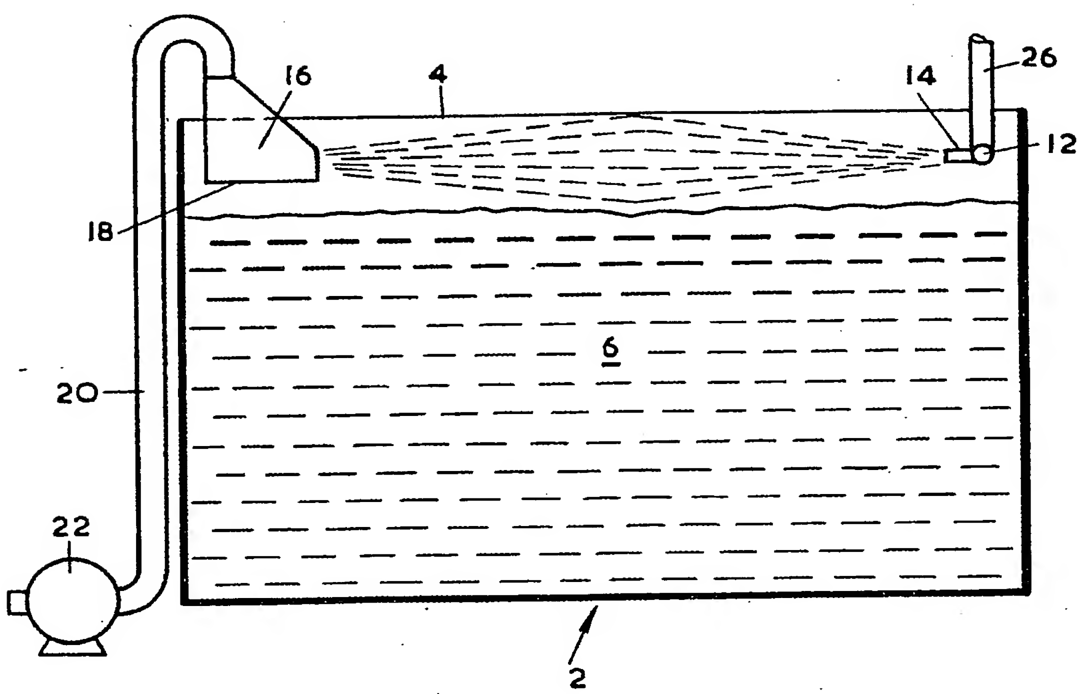

FIG.1

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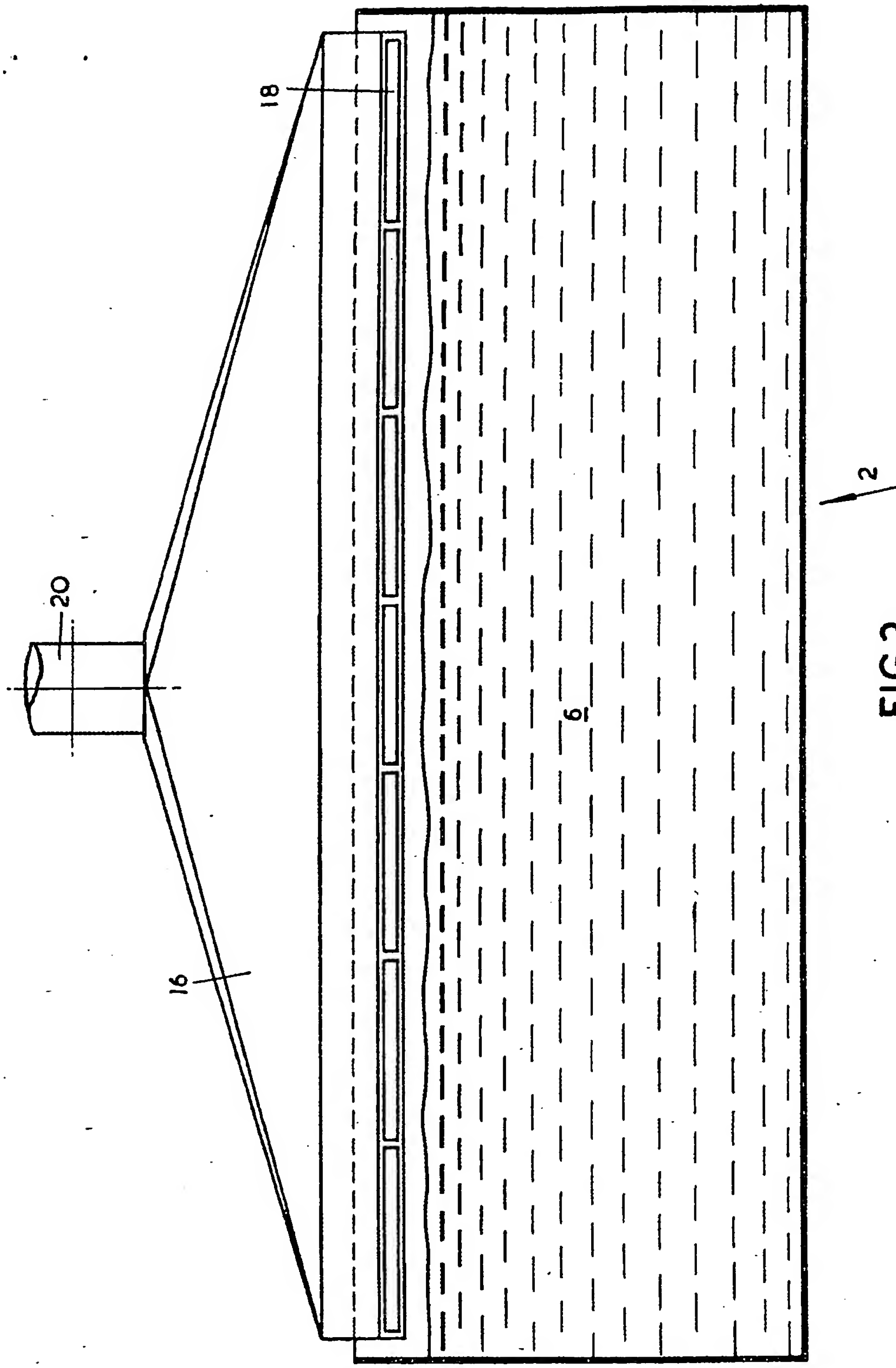

FIG.2

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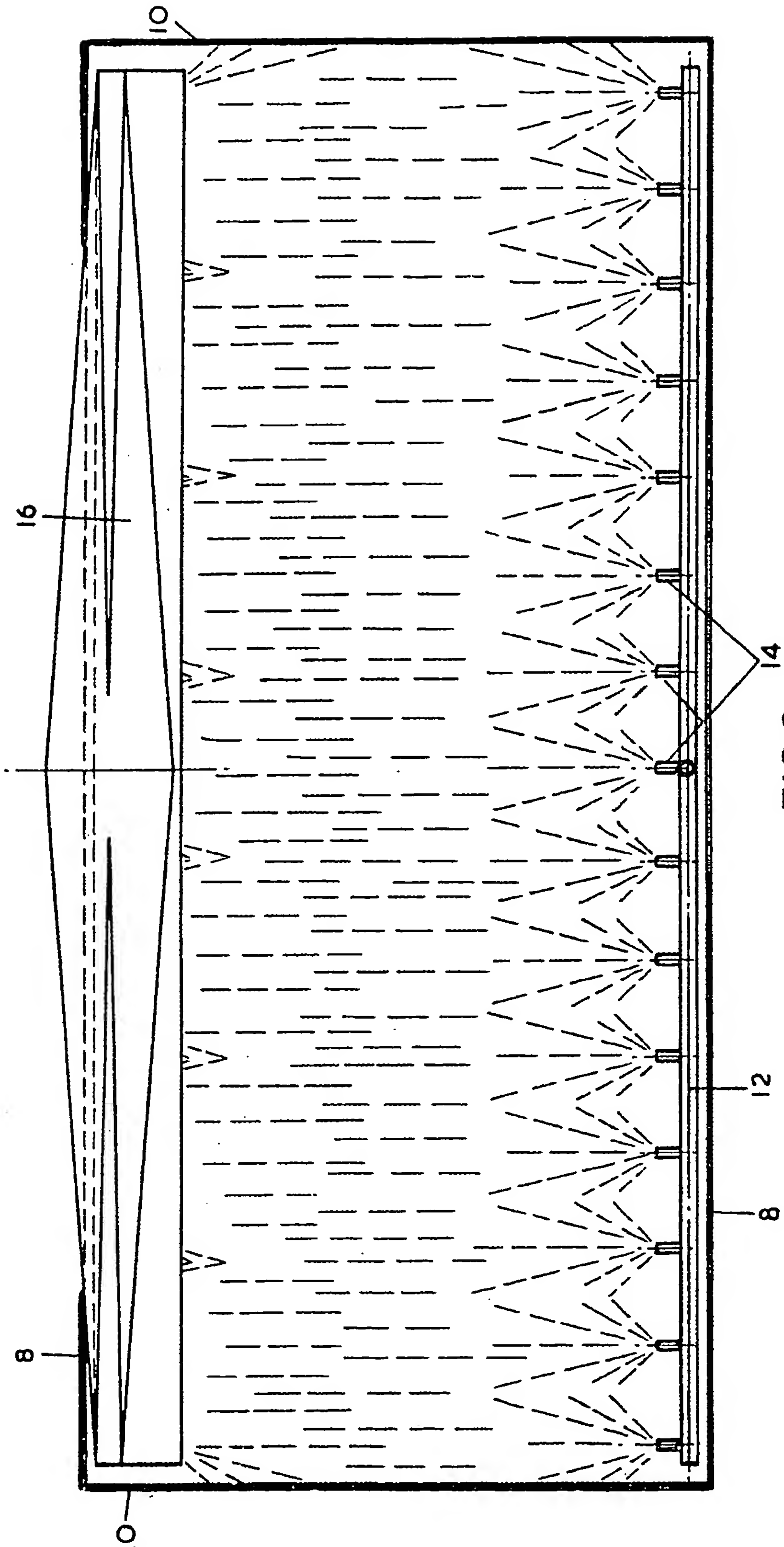

FIG.3

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SPECIFICATION

Coating with metals

This invention relates to coating with metals. In particular, it relates to a process and apparatus for coating with metal a member (or workpiece) typically of ferrous or other metal.

Galvanising steel products by dipping them in a bath of molten zinc is a process which has essentially been in use for something in the order of 200 years. The process still offers one of the best methods of protecting steel products from corrosion. As a result of the galvanising process an impervious zinc coating is formed on the parent steel. This coating is chemically bonded to the steel. Its main advantage is that it affords cathodic protection to any area in which the coating is penetrated in use of the steel product concerned. Moreover, since the coating is chemically bonded to the parent steel it offers a high resistance to mechanical damage.

One problem in performing the so-called 'hot dip' zinc galvanising process is that there tends to be a loss of the valuable zinc metal through formation of oxide at the surface of the bath of molten zinc. Since commercial tanks designed for holding molten zinc for use in the galvanising process are open-topped, there is continuous exposure of the surface to the atmosphere. It is therefore the practice of those who operate zinc galvanising baths to cover the metal surface with a suitable inorganic flux. However, such flux tends to be disturbed when the steel products are dipped into the molten zinc, and therefore use of such flux cannot eliminate oxidation. Moreover, flux, as well as any oxide formed, can be caught on the surface of products or components as they are immersed in the bath and can therefore give rise to subsequent spots of corrosion.

Traditionally, the temperature of the galvanising is in the order of 430-465°C. In the past 10 years or so, baths have been developed which enable steel components to be galvanised at higher temperatures, (for example, up to 560°C). The use of such higher temperatures enables economic coating thickness to be applied to silicon steels. These steels are generally more readily available than silicon-free steels. They are also favoured for structural applications. However, at higher temperatures, the problems associated with oxidation of the molten zinc are, we believe, more pronounced.

Analogous problems exist we believe in coating steels or other metals etc. with, for example, molten tin, aluminium or an alloy of aluminium and zinc.

It is an aim of the present invention to provide a process and apparatus for galvanising (or otherwise coating) steel components and the like which make it possible to reduce the surface oxidation of the zinc (or other metal forming the coating) in comparison with that which typically occurs in the aforementioned conventional processes.

According to the invention there is provided a process of coating with metal a member (or workpiece) including the step of dipping the member into a bath of molten metal over at least a major part of whose surface is a blanket of gas which protects the metal from oxidation, the blanket of gas being established by directing liquefied gas at or along the surface of the molten metal and thereby causing the liquefied gas to vaporise, and drawing the so-formed vapour over substantially the whole area of the aforesaid major portion of the surface of the molten metal, the liquefied gas being incapable of oxidising the molten metal under the prevailing conditions.

The invention also provides apparatus for coating with metal a member (or workpiece), including a tank for holding molten metal, means for melting the metal in the tank and maintaining it in a molten state, means for directing a liquefied gas at or along the surface of the molten metal, and at least one fan or other means for drawing vapour formed by evaporation of the liquefied gas over substantially the whole of the area of at least a major portion of the surface of the molten metal in operation of the apparatus.

The process and apparatus are particularly suitable for galvanising (with zinc) steel or other metal.

The preferred gas is nitrogen. It is, however, perfectly possible to use other gases in addition or as an alternative for nitrogen. For example, a noble gas may be used although helium is not recommended in view of its very low density. Other noble gases such as argon, xenon and krypton are acceptable from the technical point of view.

The liquefied gas is preferably sprayed at the surface of the molten metal from a relatively small distance thereabove and may collect on the surface. Upon vaporisation liquid nitrogen will undergo a large increase in volume. One volume of liquid nitrogen produces over 700 volumes of nitrogen gas. This large increase in volume makes possible adequate protection of the surface of the molten zinc (or other metal). Preferably there are a plurality of nozzles or jets for spraying liquid nitrogen towards the surface of the molten metal. These are typically located above at least one side of the area to be blanketed by the gas. Typically, this area will be substantially the whole surface area of the bath. On some occasions, however, there will be above part of the surface of the molten metal heating devices which direct hot gases at the surface so as to heat it and thereby melt the metal. In such apparatus, it will generally be possible and desirable only to blanket that surface area upon which the hot combustion gases do not impinge. Apart from the reason that the apparatus in which the hot gases are produced will by its physical presence make it difficult to direct gas at or along such surface, the hot combustion gases themselves will tend to be non-reactive with the molten metal and will therefore tend to protect the molten metal against oxidation.

Typically, liquefied gas may be sprayed at the surface of the molten metal from several or many spaced apart nozzles all situated above and along one side of the tank. In such an arrangement, it is preferred that one or more fans be used to create a

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suction which draws the nitrogen or other gas across the tank to the opposite side where it is collected in one or more hoods or other gas collecting devices which are situated upstream of the fan. By choosing an appropriate spacing of the nozzles or jets from which the liquefied gas is sprayed at the surface of the molten metal, it is possible to ensure that substantially all the surface is covered by a blanket of nitrogen or other gas.

The use of a liquefied gas such as liquid nitrogen in the process according to the invention makes it possible to flush away oxygen in the air without creating turbulence. By drawing the nitrogen across the surface of the molten zinc, it is possible to prevent (or at least keep down the amount of) air that is drawn through the non-reactive gas by means of thermal currents. It is nontheless desirable to have a flow of nitrogen across the surface of the molten zinc (for example, a gas flow in the order of, say, 0.05 to 5mm/second, may be created).

Typically, there may be a hood or cowl which has an inlet opening above the tank and running substantially along one side of the tank. The cowl or hood preferably has an outlet which runs downwardly towards or to the bottom of the tank. This outlet conduit may typically have the fan situated at its inlet or outlet end.

Other arrangements of spray means and gas collecting means are possible. It is, for example, possible to direct the liquid sprays from the centre of the tank outwards and collect the resultant gas in suitable hoods around the periphery of the tank. Each hood may have its own fan, or alternatively, there may be a single fan serving both or all the hoods.

The process and apparatus according to the invention are suitable for use with any kind of galvanising bath. The metal may be heated from above, below, or the side. Another possibility is for the heaters to be located within the bath itself. The heating may be electric or by means of fuel burners.

The tank may be of steel, and if desired, may have a ceramic or other lining.

By adopting the process and apparatus according to the invention it is, we believe, possible when galvanising steel to reduce or even eliminate altogether use of inorganic flux to protect the surface of the molten bath. In addition, we believe it is possible using the process and apparatus according to the invention to reduce the rate of oxidation of the zinc.

The process and apparatus according to the invention is suitable for use when it is desirable to prevent oxidation of the molten metal. Examples of such uses include the coating of ferrous and non-ferrous components by dipping them in molten tin, aluminium or zinc-aluminium alloy.

The process and apparatus according to the invention will now be described by way of example with reference to the accompanying drawings, of which:

Figure 1 is an end view of a zinc galvanising bath adapted to perform the process according to the invention;

Figure 2 is a plan view of the bath shown in Figures 1 and 2.

Referring to the drawings, a zinc galvanising bath 2 is generally cuboid in shape and has an open top 4. The tank 2 is shown as containing a volume 6 of molten zinc. The tank 2 has a pair of longer sides 8 and a pair of shorter sides 10.

The tank 2 has means for heating the zinc but these means are not shown and it is not necessary to do so for an understanding of the invention. With reference to Figures 2 and 3, extending from close to one of the shorter ends but close to the other and situated above the molten zinc in the tank 2 is a spray-header 12. The spray-header has a plurality of spray nozzles 14 which are horizontally disposed but in operation, direct nitrogen at and along the surface of the molten metal. As shown, there are 15 spray nozzles, the space between each pair of nozzles being 1/14 of the total length of the adjacent side 8 of the tank 2. Typically, the spray-header 12 is located within inches of its adjacent side 8 of the tank 2 and runs parallel to the side.

Running from one side 10 of the tank 2 to the other adjacent side 8 opposite to where the spray-header 12 is located is a hood 16. The hood 16 is adapted to receive nitrogen flowing across the surface of the molten zinc from the spray-header 12. Thus, the inlet 18 to the hood 16 directly faces the nozzles 14 of the spray-header 12. The hood 16 has an outlet 18 in communication with a conduit 20 which runs down to the base of the tank adjacent the exterior surface of one of the sides 8 to which the hood 16 is adjacent. The conduit 20 terminates in a fan 22 whose outlet communicates with the atmosphere.

Liquid nitrogen for the spray-header 12 is supplied from a vacuum insulated tank (not shown) by means of an insulated supply line 26. Typically, both the nozzles 14 and the body of the spray-header 12 will also be insulated. In operation, zinc ingots are loaded into the tank 2 and melted by means of the heaters (not shown). Once the zinc is molten liquid nitrogen is passed under pressure into the spray-header 12. Liquid nitrogen issues from the nozzles 14. In view of the temperature of the molten zinc (typically 450°C) some liquid nitrogen will vaporise as it leaves the nozzles 14. (Indeed, some vaporisation may also occur within the nozzles themselves.)

As a result of the vaporisation, the nitrogen increases in volume at least 700 times. The whole vicinity of the surface of the molten zinc in the vicinity of the spray header 12 thus becomes blanketed with nitrogen gas. By starting operation of the fan, nitrogen is drawn across the surface of the molten zinc as shown by the arrows in Figure 3. Nitrogen flows across substantially the whole of the surface area of the bath between the spray header 12 and the mouth or inlet 18 of the hood 16. The passage of liquid nitrogen into the spray header 12 is continued so that this flow of nitrogen across the surface of the molten metal is maintained. The juxtaposition of the nozzles 14 and the hood 18, and the flow rate of liquid nitrogen into the spray header 12 is such that, in effect, a blanket of nitrogen is maintained over substantially the whole of the free surface area of the bath. It is thus, we believe, not necessary to sprinkle flux onto the surface of the molten zinc so as to protect it from oxidation.

The nitrogen which is drawn by the fan through the conduit 20 may be vented to the atmosphere.

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In order to galvanise steel products, they may be loaded into a basket which is then immersed totally in the molten zinc. This operation is performed without altering the flow of nitrogen to the spray header 12. It is possible to immerse large components directly in the molten zinc without the use of a basket by lowering such components into the bath by means of a crane. The process can also be used to coat individual articles or for the continuous coating of wire and strip.

The steel components are removed from the bath when they have been treated for a suitable time.

CLAIMS

1. A process of coating with metal a member (or workpiece) including the step of dipping the member into a bath of molten metal over at least a major part of whose surface is a blanket of gas which protects the metal from oxidation, the blanket of gas being established by directing liquefied gas at or along the surface of the molten metal and thereby causing the liquefied gas to evaporate, and drawing the so-formed vapour over substantially the whole area of the aforesaid major portion of the surface of the molten metal, the liquefied gas being incapable of oxidising the molten metal under the prevailing conditions.

2. A process as claimed in claim 1, in which the molten metal is zinc.

3. A process as claimed in claim 1 or claim 2, in which the member is of steel.

4. A process as claimed in any of the preceding claims, in which the liquefied gas is liquid nitrogen.

5. A process as claimed in any of the preceding claims in which the liquefied gas is sprayed at the surface of the molten metal.

6. A process as claimed in claim 5, in which the liquefied gas is sprayed at the surface of the molten metal from several or many spaced apart nozzles all situated above and along one side of the bath.

7. A process as claimed in claim 6, in which one or more fans are used to create a suction which draws the vapour across the bath to the side thereof opposite the side above which are the nozzles.

8. A process of coating a member with metal substantially as herein described with reference to the accompanying drawing.

9. A member or workpiece coated with metal by a process as claimed in any one of the preceding claims.

10. Apparatus for coating with metal a member (or workpiece), including a tank for holding molten metal, means for melting the metal in the tank and maintaining it in a molten state, means for directing a liquefied gas at or along the surface of the molten metal, and at least one fan or other means for drawing vapour formed by evaporation of the liquefied gas over substantially the whole of the area of at least a major portion of the molten metal in operation of the apparatus.

11. Apparatus as claimed in claim 10, in which the means for directing the liquefied gas at or along the surface of the molten metal are a plurality of nozzles which in use create sprays of the liquefied gas.

12. Apparatus as claimed in claim 11, in which the nozzles are situated above at least one side of the area to be blanketed by the gas.

13. Apparatus as claimed in claim 12, in which the nozzles are situated above and along one side of the tank.

14. Apparatus as claimed in claim 13, in which one or more fans are used in operation of the apparatus to create a suction which draws the vapour across the tank to the other side of the tank.

15. Apparatus as claimed in any of claims 10 to 14, additionally including means for collecting the vapour which has, in operation of the apparatus, passed over the chosen surface area of the molten metal.

16. Apparatus as claimed in claim 15 in which the collecting means are one or more hoods or cowls.

17. Apparatus for coating with metal a member (or workpiece), substantially as herein described with reference to and as shown in, the accompanying drawings.

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